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Comparative Cost Analysis of Domestic Container Shipping Network: A Case Study of Indonesian Sea-Toll Concept

Analisis Perbandingan Biaya Pada Jaringan Pelayaran Kontainer Domestik: Studi Kasus Konsep Tol Laut Indonesia

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Abstract

The Logistics Performance Index (LPI) of Indonesia shows minor improvement compared to neighbouring countries such as Singapore and Malaysia. The economic disparity between Indonesia's eastern and western regions has reportedly become one of the fundamental problems in the country. Consequently, an ambitious project on shipping connectivity improvement, namely the 'Sea-Toll', has been proclaimed by the Indonesian government to overcome this chronic problem. One of the most influential parameters for measuring the success rate of this project is cost efficiency. Therefore, this paper proposes a comparative approach by constructing a generalised cost model. It develops a measurement for transport costs that combines actual freight cost with the value of time attached to delivery activities concerning cargo types. Overall results study depend on the shipping network is described in terms of a current and future condition. This condition is because the factor of economies of scale has a significant influence in the combination of actual empirical data and extractions of regression approach with the function of vessel size. Finally, all scenarios show that there is a positive relationship with a convincing impact on efforts to save costs for domestic shipping routes after the implementation of the sea-Toll program.

Keywords: *Generalised Cost, Container Shipping, Economies of Scale, Sea-Toll, Domestic Trade Network, Port Infrastructure*

Abstrak

Logistic Performance Index (LPI) Indonesia tidak menunjukan perbaikan yang signifikan bahkan jika dibandingkan dengan negara tetangga seperti Singapura dan Malaysia. Kesenjangan ekonomi antara wilayah timur dan barat Indonesia dilaporkan menjadi salah satu masalah mendasar di negara ini. Sebagai akibatnya, sebuah program ambisius pada peningkatan konektivitas pengiriman, yaitu proyek Tol-Laut, telah diproklamasikan oleh pemerintah Indonesia untuk mengatasi masalah yang kronis ini. Salah satu parameter paling efektif untuk mengukur tingkat keberhasilan proyek ini adalah efisiensi biaya; selain itu, keberadaan variabel non-moneter perlu diperhitungkan. Oleh karena itu, artikel ini mengusulkan pendekatan komparatif dengan membangun model berbasis generalised cost. Model ini mengembangkan pengukuran untuk biaya transportasi yang menggabungkan biaya pengiriman aktual dengan nilai waktu yang melekat pada selama proses pengiriman dalam kaitannya dengan jenis kargo. Hasil keseluruhan dari penelitian ini tergantung pada bagaimana jaringan pengiriman dijelaskan pada kondisi saat ini dan masa depan. Ini karena feconomies of scale memiliki pengaruh besar dalam kombinasi data empiris aktual dan ekstraksi pendekatan regresi dengan fungsi ukuran kapal. Akhirnya, semua skenario menunjukkan bahwa adanya hubungan positif dengan dampak yang meyakinkan dalam upaya penghematan biaya untuk rute pengiriman domestik setelah pelaksanaan program Tol-Laut.

Kata Kunci: *Generalised Cost*, Pelayaran Peti Kemas, *Economies of Scale*, Tol-Laut, Jalur Perdagangan Dalam Negeri, Infrastruktur Pelabuhan

1. Introduction

This particular study is conducted to comprehensively analyse the Indonesian container shipping network in regard to cost perspective by comparing the conditions between the current state and after the implementation of the maritime transport improvement program. Whereby, the ultimate goal of this study is to comprehensively seize the manner of both primary internal and external factors that influence the Indonesian maritime-based economy in general which would help the authorities to take a decision.

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As we know, Indonesia is by far the biggest archipelagic country in the world with more than 17,000 islands and 5.8 million km2 of sea area. This geographical issue has made it challenging to serve a good domestic logistic network. In fact, the latest LPI data report shows that Indonesia still needs a lot of improvement. LPI is a globally used parameter issued in every 2 (two) years by World Bank to measure the achievement of logistics performance from 160 countries. LPI has 6 (six) main indicators that will later define the overall score as follows (The World Bank, 2016) 1) Customs; 2) Infrastructure; 3) Ease of arranging international shipments; 4) Logistic competence; 5) Tracking and tracing; and 6) Timeliness .

Indonesia's LPI achievement is gradually increasing over the last 10 years. It is showed by a significant jump to 46th rank in 2018 from 63rd rank in 2016. However, when compared to the achievements of neighboring countries, such as Singapore, Thailand and Malaysia. With its vast territory and consists of thousands of islands, seaborne trade still become a backbone for logistics performance in Indonesia. The figure 1 shows the quality of port infrastructure that also published by The World Bank.

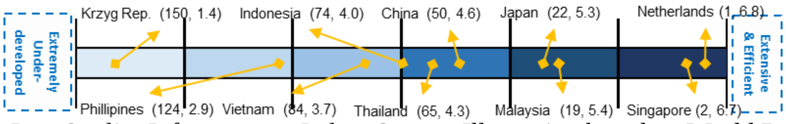

Figure 1. Port Quality Infrastructure Index. *Source*: Illustration based on World Bank, 2017

Furthermore, Indonesia is now preparing to be a maritime nation because it is one of the four pillars under the current government. The President of Indonesia, Mr. Joko Widodo, has a vision to turn Indonesia into a global maritime axis (Shekhar and Liow, 2014). As a form to manifest this vision, strong inter-island connectivity and improvement in port infrastructure are necessary. Thus, an ambitious program to improve the current state of shipping network in Indonesia is underway namely the Sea-Toll. The cost efficiency still becomes the most important parameter to measure how successful the program would be to support the national maritime-based economy.

Hence, this study focused in presenting the domestic shipping network for the national trade of containers in particular. It dominantly discusses the linkage between major ports in Indonesia. However, it is not as simple as it seems due to the uneven development between western and eastern parts of Indonesia. The east has relatively a small volume of trade to bargain. In this study we will focus how much cost needed to ship a cargo from port-to-port limited to maritime leg cost and cost incurred in port area but not considering the cost in hinterland transport as illustrated in figure 2.

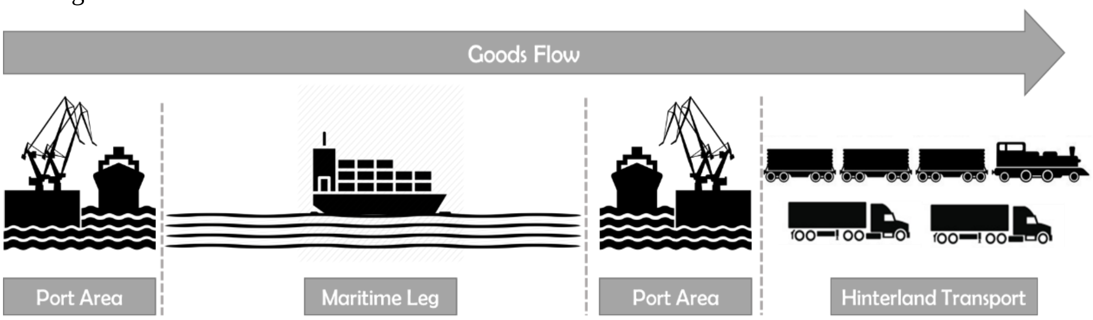

Figure 2. Goods Flow

The cost model will follow generalised cost model that will constitute both monetary and non-monetary cost in the unit of cost per TEU. Examining this subject will give an idea about shipping route patterns, taking into consideration the priority of commodities being traded from or to various regions in Indonesia. Therefore, this study is quite relevant to estimate cost-savings by comparing the current and future conditions in Indonesia.

2. Methodology

Indonesian Port Regime and Fleet Update in Current State

In the Masterplan for Acceleration and Expansion of Indonesia (MP3EI), Indonesia is divided into six main economic corridors namely Sumatera, Java, Kalimantan, Sulawesi, Bali-Nusa Tenggara, and Papua-Maluku based on the potentials and advantages of each region which intention is to reduce the dominance of Java. The twenty-two different activities clustered into six economics corridors. But, for simplification, in this study, we combined all the eastern region into Sulawesi and The Rest corridor. Figure 3 depicts an illustration of 10 major container ports that will be used to represent the national interest on connecting all main economic corridors. Each corridor has their main economic activity that will further be discussed in the following section of this chapter.

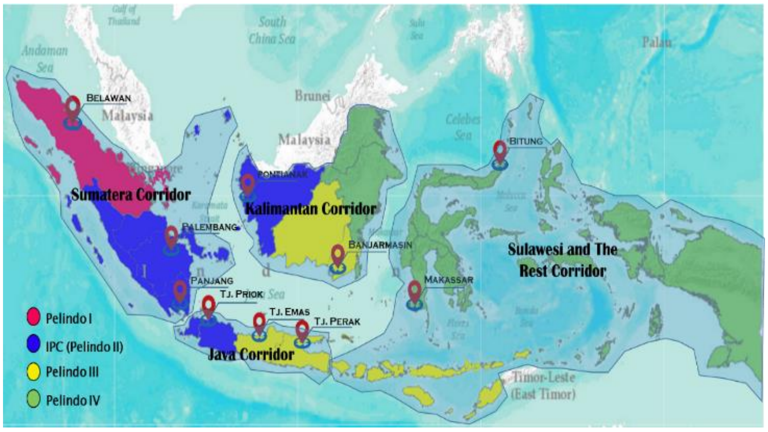

Figure 3. Illustration of Indonesia Port Regime with 10 Major Container Ports

Source: Author's illustration based on Pelindo, 2016 and Coordinating Ministry for Economic Affairs, 2011

Considering the nature of ports in Indonesia as well as the objective of researching containerised cargoes only, this study focuses on hub and feeder ports with a few dry ports involved. Currently, the Indonesian ports regime is governed by Government Regulation No. 64 of 2015, which is derived from civil statutes of the 2008 Shipping Law. As of 2013, there are approximately 2155 ports spread out over the country. Out of that number, 111 ports are classified as commercial ports and governed by four state-owned companies, namely Indonesian Port Corporations (IPCs) or Pelindo I, II, III and IV. In addition, there are also 1130 non-commercial ports and 914 dedicated private ports for the needs of private or other state-owned companies. Therefore, classifying which port has what function is necessary for this project.

Nevertheless, not all mentioned ports provide services on handling the containerised cargoes. Hence, we collected data from various sources to classify major container terminals in Indonesia. In this early stage, we used reliable studies on Indonesian maritime networks and officials' reports from several years ago as a step to determine the selection of major ports. Ray (2008) found that between 2005 and 2007, there were at least nine different container ports consisted of Belawan, Palembang, Panjang, Pontianak, Tanjung Priok, Tanjung Emas, Tanjung Perak, Makassar and Bitung ports based on their annual throughput. However, Ray's findings need to be corrected because the data used were still mixed data between domestic and international cargoes. Therefore, Table 1 below shows us the latest data between 2014 and 2016 which has already been separated for domestic containerised cargoes only. The most striking difference from (Ray, 2008) is that there is the addition of Banjarmasin port to the list that has been connecting Kalimantan to other regions in the last eight years (Pelindo III, 2016). Thus, there will be ten container ports which are considered as major ports in Indonesia and are currently used to represent domestic trade in Indonesia.

Table 1 Annual Throughput of Container Domestic Trade in Ten Major Ports

Region and Port Branch	**Domestic Container Volume (in Thousand TEUs)**			**Port Market Share**
	2014	**2015**	**2016**	
Sumatera-Belawan	479	550	792	74.13%
Sumatera-Panjang	22	25	20	3.36%
Sumatera-Palembang	56	54	55	7.28%
Sumatera-Others	-	-	156	15.23%
Java-Tj. Priok (Jakarta)	1,964	1,818	1,976	50.03%
Java-Tj. Perak (Surabaya)	1,791	1,854	1,957	49.53%
Java-Tj. Emas (Semarang)	25	20	18	0.44%
Kalimantan-Pontianak	211	209	222	25.43%
Kalimantan-Banjarmasin	414	388	408	47.27%
Kalimantan-Others	-	-	237	27.30%
Sulawesi-Makassar	533	530	581	49.67%
Sulawesi-Bitung	199	198	216	18.57%
Others	-	-	371	31.77%
Throughput of 10 Major Ports	5,692	5,646	6,243	
Annual Growth	-	-0.81%	10.58%	

Source: Adapted from Pelindo I, II, III and IV (2016) and Drewry (2012)

As an archipelagic country, the Indonesian shipping industry is subject to the 2008 Shipping Law No. 17 which replaced the 1992 law. The 2008 Shipping Law is created in general form which covers 355 articles with any further detail will be provided with other technical regulations for instance is Ministerial Decree or Government Regulation. In essence, this law comprises a full range of issues connected to shipping such as navigation, seafarer's welfare, collision and maritime accidents, environmental protection, community participation, coast guard, etc. (Ray, 2008). Nevertheless, it can be seen that the most fundamental value-added, especially for the domestic shipping industry, is the provision of cabotage. Cabotage principles control the shipping activities within Indonesia's jurisdiction and restrict the operation of foreign vessels on its territories (Rose, et al., 2012). A genuine purpose of this principle is to ensure domestic shipping business. Article 8 of the 2008 Shipping Law underlined two fundamental principles, firstly, any activities related to domestic shipping must be performed by a company registered under the Indonesian flag and manned by an Indonesian citizen. Secondly, it has the implication that non-Indonesian flagged vessels are banned from implementing any form of freight and passenger carriage between islands or ports of Indonesia. Moreover, the 2008 Shipping Law also stipulates that any company with foreign shareholders must own at least one ship with a size of more than 5000 GT. In addition, foreign shareholders can be limited up to 95% of their share accordingly (Rose, et al., 2012). Table 2 shows a set of information about domestic shipping routes and fleet update from the big-five of container carriers in Indonesia.

Table 2 shows that the most attractive ports for domestic trades are mainly Jakarta, Surabaya and Makassar. Using this fact, we will build a model of domestic shipping network and estimate the generalised cost of the current situation that likely follow the hub-and-spoke model to gain increase shipping line network and gain competitive advantage (Notteboom and Rodrigue, 2005; Hsu and Hsieh (2007)

Table 2 Domestic O-D Routes and Fleet Update of Top Five Container Liners

Company	Domestic O-D Routes		Allocated Ships
	Home-ports	**Main Ports of Call**	
Samudra Shipping Line	Jakarta	Banjarmasin; Pontianak; Palembang	±14 Container Ships Total Fleet: 3657 TEU Biggest Vessel: 378 TEU Smallest Vessel: 115 TEU Average Fleet: 262 TEU
	Surabaya	Banjarmasin; Sampit; Samarinda; Makassar	
Meratus Line	Jakarta	Belawan; Makassar; Padang; Semarang, Surabaya	±56 Container Ships Total Fleet: 37,929 TEU Biggest Vessel: 2,113 TEU Smallest Vessel: 120 TEU Average Fleet: 678 TEU
	Semarang	Surabaya, Banjarmasin	
	Surabaya	Bitung; Banjarmasin; Belawan; Sampit; Pontianak; Makassar Samarinda; Balikpapan	
	Makassar	Kendari; Bitung; Kupang; Ambon; Surabaya; Jakarta	
Tempura Emas Line	Jakarta	Pontianak; Pekanbaru; Dumai; Palembang; Batam; Samarinda; Palu; Belawan; Surabaya	±34 Container Ships Total Fleet: 25,785 TEU Biggest Vessel: 2,702 TEU Smallest Vessel: 283 TEU Average Fleet: 759 TEU
	Surabaya	Makassar; Balikpapan; Banjarmasin; Jayapura; Ambon; Manokwari;	
	Makassar	Bitung; Sorong; Palu; Ambon; Timika; Kupang; Merauke; Surabaya; Fakfak;	
Salam Pacific Indonesia Line (SPIL)	Jakarta	Banjarmasin; Surabaya; Samarinda; Pontianak; Belawan; Pekanbaru; Batam;	±43 Container Ships Total Fleet: 32,959 TEU Biggest Vessel: 2,526 TEU Smallest Vessel: 200 TEU Average Fleet: 916 TEU
	Surabaya	Banjarmasin; Samarinda; Balikpapan; Sampit; Makassar; Bitung; Belawan;	
	Makassar	Banjarmasin; Balikpapan; Ternate; Ambon; Sorong; Manokwari; Jayapura; Fakfak; Merauke	
Tanto Line	Jakarta	Balikpapan; Banjarmasin; Pontianak; Makassar; Belawan; Batam; Padang; Samarinda; Surabaya	±30 Container Ships Total Fleet: 26,731 TEU Biggest Vessel: 1,525 TEU Smallest Vessel: 120 TEU Average Fleet: 661 TEU
	Surabaya	Balikpapan; Banjarmasin; Makassar; Belawan; Bitung; Samarinda; Lampung	
	Makassar	Jayapura; Ambon; Sorong; Kendari; Ternate; Manokwari;	

Source: Adapted from (Drewry, 2012), (Samudera Indonesia, 2017), (Meratus, 2017), (Temas Line, 2017), (SPIL, 2017) and (Marine Traffic, 2017)

The Role of Singapore for The Circulation of Goods in Domestic Network

The Port of Singapore is by far larger than any other port in Indonesia with respect to annual capacity. Currently, Singapore has the upper hand by having five times bigger volume than Tanjung Priok port, which is known as the largest port in Indonesia. Nevertheless, apart from the competition of seizing market power in the South East Asian region between both countries, the role of Singapore in supporting Indonesian logistic needs is still essential. It is inevitable that most of the time, many goods from all over the world, especially ones from the Europe-Far East route need to be unloaded in Singapore first before reaching Indonesia. Below are several lists of container shipping routes within Indonesian territory for domestic logistic fulfilment purpose which involve Singapore ports as a medium. This data was collected through an interview with one of the consultants working in the branch office of The World Bank in Indonesia who had studied mapping international shipping line networks through Indonesia.

Table 3 Container Shipping Route Between Indonesia and Singapore

Shipping Routes	Annual Trip Amount (In TEUs)
Tanjung Priok - Singapore	399,314
Tanjung Emas - Singapore	61,978
Belawan - Singapore	182,123
Tanjung Perak - Singapore	280,076
Pontianak - Singapore	7,973
Palembang - Singapore	4,947
Panjang - Singapore	5,096

Source: Adapted from Fahmiasari, 2017, Clarkson and Pelindo, 2016

The figures in Table 3 show that the container trade between Indonesia and Singapore is about 942,107 TEUs, unbelievably small compared to the total throughput of 30.9 million TEUs of Singapore. This figure is also small compared to the domestic annual throughput of four IPCs as shown in Table 1. Thus, we believe that the transhipment in Singapore is most likely not the hub-and-spoke, but more inter-liner or relay transhipment, i.e. between mainlines. Moreover, it means that each economic corridor in Indonesia generates its containers to support the circulation of goods within the country. However, these findings show that the relationship between Singapore and Indonesia in feeding the circulation of goods still exists.

The Sea-Toll Project

The Indonesian Sea-Toll is a program established to the diminish national logistic problem that is mostly still concentrated in the western part of the country. Previously, the Indonesia Port Corporation (Pelindo II) tried to solve this issue by developing a similar concept, namely the Nusantara Pendulum, which is making regular shipping schedules from Belawan in North Sumatera to Sorong in West Papua and vice versa, just like how a pendulum works (Fahmiasari and Parikesit, 2017). This Pendulum program helps to create better connectivity between the eastern and western regions of Indonesia that will further boost economic growth by generating more cargoes based on the eastern regions (Drewry, 2012). Nonetheless, Drewry also pointed out that this Pendulum service might be challenged, as highly competitive container carriers may lose some profit due to imbalanced trade volume and freight rates in some routes of the east-west corridor. Thus, the current President of Indonesia, Joko Widodo, initiated the Sea-Toll concept presumably is the modification of Pendulum service which mitigating the eastern hub in Indonesia from previously Sorong port to Bitung port (Fahmiasari and Parikesit, 2017).

According to Drewry's report in the Business Review on Domestic Container Main Sea Corridor (2012), Indonesia has been gradually growing in most of its sector. The results showed that Sumatra is firmly an agriculture-based economy in which more than 20% of total Sumatera GDP comes from this sector. Kalimantan contributed almost 11% of total Indonesia GDP in 2011 all from the timber industry alone; this contribution was apart from oil, gas and coal — also superior sectors in this region. Sulawesi is the largest marine fish producer in Indonesia as well as the biggest contributor to the national production of cocoa with a 63% share. Meanwhile, Maluku, Papua and the rest also rely on a large portion of their commodities in agriculture, livestock and mining such as nickel and gold to accelerate growth. It is expected that in 2018, there will be 10,000 TEUs containerised nickel to be transhipped annually to Bitung port before their final destination (Drewry, 2012). On the other hand, Java as the leading corridor has an upper hand in the manufacturing sector such as electronics, automotive, machinery and equipment industries. Drewry reported that about 18% of total container traffic in 2011 generated by the rest of Indonesian provinces had been collectively connected with domestic shipping carriers to either Tanjung Priok or Tanjung Perak for transhipment to international routes or for local absorption in Java due to large consumer size and vice versa. This following table shows the projection of domestic container traffic for each corridor.

The Sea-Toll could be the best solution to manifest the projected goals in 2030 by connecting all economic corridors with an integrated and low transport cost container shipping network. However, the financial issue has been one of the greatest obstacles which the Indonesian government is facing right now to realise the biggest ambitious project among Southeast Asian nations (Mooney, 2017). Currently, the Indonesian government is focusing on preparing well-equipped infrastructure as a fundamental aspect to support this program. The background is because most of the Indonesian ports do not have sufficient draft and adequate facilities to accommodate vessels with a size of more than 2000 TEU. In conclusion, the division of economic corridors is to accelerate Indonesian economic growth while the Sea-Toll concept is a manifested tool that aims to realise all targets.

Therefore, the Indonesian government has planned and evaluated to develop 24 strategic ports, especially the five largest ports among others that will be used as domestic hub ports. Currently, several redevelopment projects have taken place, for example, the groundbreaking of Kuala Tanjung port has started on January 25th, 2015 whereby procurement of heavy equipment such as RTG, mobile electric power, new container crane and dredging also takes place at the Bitung port (Bappenas, 2015). Furthermore, the New Priok Container Terminal (NPCT) has been operating since 2016 to handle international freight trade. Furthermore, apart from this physical development, the government through the Directorate of Sea Transportation has declared a decree of AL-108/6/2/DJPL-15 to subsidise and ensure a regular freight shipping schedule in several routes in the eastern part of Indonesia (Directorate General of Sea Transportation, 2015).

In conclusion, a massive contributor with the implementation of the Sea-Toll concept is the economies of scale. Having the economies of scale mostly affects the maritime shipping area as the unit cost tends to decrease in favour of an increase in a ship's capacity. Meanwhile, the positive effect of the growth of vessel size will stop at some point and turn into increasingly problematic issues to cope with port authorities and terminal operators. Due to this condition, the port must improve their capacity service by having massive investments in larger cranes, temporary warehouse and wider terminal areas, which lead to diseconomies of scale (Rodrigue, 2017).

Generalised Transport Cost Model

A generalised cost method has been well-known used with a far-reaching area for economic analysis and decision-making in the public-sector due to its simplicity. It is undoubtedly adjustable with such a degree of freedom considering the decision maker's characteristics such as the type of transport mode, supporting infrastructure, the relation between origin and destination, nature and size of the organisation, product features, shipment size, etc. (Tavasszy, 1996). Recent research conducted by Fahmiasari (2016) also shows that in essence, generalised transport cost considers several aspects to generate a final product of transportation cost such as the value of time, costs occurred by damage and loss, reliability costs, holding costs, and administrative expenses which data were gathered from various sources (e.g Clarkson Database Intelligence). In general, generalised cost model is formed as the equation below (Grey, 1978):

$$GC = \sum_1^m m_i M_i + \sum_1^t t_i T_i \qquad (1)$$

Where, Mi are the actual monetary costs of the voyage, it could be freight rate costs, fuel costs, and maintenance costs. Meanwhile, Ti are the various components of non-monetary costs.

We construct the formula of generalised cost for this study in two main areas of maritime leg and port are. The concept to measure generalised cost in the maritime leg by Van Hassel et al. (2016) approach combined with the idea of shipping costs of Stopford (2009) as well as several adjustments considering the nature of Indonesian shipping.

$$GC_m = \frac{\left[(FC_j + LUB_j).\frac{Dist_k}{V_j}\right] + I_j + RM_j + CC_j + MA_j + CapC_j}{N_{TEU}} + \sum_1^m VoT.T_m \qquad (2)$$

Where, GC_m is generalised cost in maritime leg, FC_j is fuel cost, LUB_j is lubricant cost, RM_j is repair and maintenance cost, CC_j is crew cost, $CapC_j$ is annual capital cost, $Dist_k$ is voyage distance, I_j is insurance cost, MA_j is management and administration cost, V_j is speed of ship, N_{TEU} is number of transported containers, VoT is value of time and T_m is total maritime time of O-D (Origin to Destination).

On the other hand, the formula to measure generalised cost in port area is derived from Fahmiasari (2016) approach as showed as follow:

$$GC_p = \frac{PD_j + CH_j + SC_j}{N_{TEU}} + \sum_1^p VoT.T_p \qquad (3)$$

Where, GC_p is generalised cost in port area, PD_j is port dues, CH_j is container handling cost, SC_j is storing cost, VoT is value of time, T_p is total time spent in port of origin and destination and N_{TEU} is number of containers.

All equations (1), (2) and (3) above have included the variable of time whether it is the real of monetary cost like port dues (i.e. costs of anchorage, pilotage, tugging and berthing) or the non-monetary cost represented by cost incurred due to the value of time. Since the whole calculation are in the unit of TEU, thus the load factor of ship becomes very critical in this model, we assume that every ship to have 80% of its capacity is fully loaded for every single route for both current and future condition using the Sea Toll concept.

Cost Incurred as Change in Vessel Size (Economies of Scale)

Cullinane and Khanna (1999) developed a model to quantify the effect of the economies of scale for large containerships. They found that unit cost per TEU will decrease proportionally as the vessel size grows. However, they made a very important remark saying that the overall efficiency strongly depends on the total journey time to complete a trip. As consequence, time becomes a crucial factor, especially, the time spent in port as bigger vessel needs to have relatively longer cargo-handling period. Therefore, there is a trade-off between the positive results gained in maritime leg and the negative returns accumulated in port area due to handling activities (Cullinane and

Khanna, 1999; Javier *et.al*, 2010).

Economies of scale for the ship can be associated with capital related, manning, fuel and handling cost with an also time-related cost that perfectly matched with generalised cost. According to (Veldman, Liu and Garcia-Alonso, 2016), there are two ways to capital related costs are based on the price of the ship in the market. The ship's price (P) can be expressed as the following formula which structured by the size and speed of the ship and has nothing to do whether the ship is from new building or second-hand condition.

$$P = \alpha_0 S^{\alpha_1} V^{\alpha_2} \quad (4)$$

Where the size factor (S) is expressed in TEU, and designed service speed (V) is in knots. Meanwhile, α1 and α2 are the elasticity value of size and speed, respectively. Using the regression analysis based on WSE container ship data of 2008, Veldman (2011) showed later that the value for α1 and α2 are 0.726 and 0.0235, respectively. But if the ship's capacity is below the Panamax size, which is the case in this study, the only consideration to define ship's price is its size. Consequently, there will be a change in α1 to 0.766 in which we will apply this value from now on.

For example, to extract information about vessel price from the regression model, we use a parameter of newbuilding vessel price with the size of 1000 TEU from The Clarkson intelligence database (Clarkson, 2016). The basis data for vessel price is 17.2 million US Dollars. Since the range of ship size for domestic trade in current condition is from 200 to 1600 TEU, and the biggest projected size for the future state is 3000 TEU, we make a regression model starting from 200 to 3000 TEU. Next, by reflecting Equation 4, we scale the vessel price for different ship size whereby the results are presented in Figure 4.

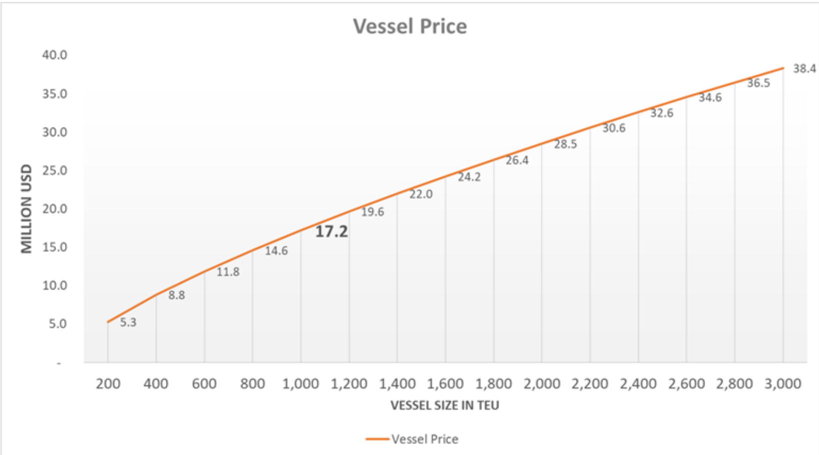

Figure 4. Regression of Vessel Price

On the other hand, advanced technology level of ship equipment, the number of ship's crews and their nationalities, as well as the voyage pattern, will determine the manning cost (L). Although, all of those elements are less likely have anything to do with ship's size, thus, the elasticity value of ε1, according to equation (7), tends to be zero. Nonetheless, in his paper, Veldman (2011) noted that the value of ε1 is approximately 0.03.

$$L = \varepsilon_0 S^{\varepsilon_1} \quad (5)$$

Using the rule of thumbs, fuel cost emerges from the engine power which according to Jansson and Shneerson (1987), the engine power produced is equal to the two-third power of the displacement multiplied by the cube of the design speed. Whereby the equation (8) shows the engine power to some extent is also a function of ship size and speed expressed as a function of vessel size and speed. The regression analysis based on WSE 2008 data showed that the elasticity value of ship size (γ1) is 0.586 and 2.008 for the velocity of the ship (γ2) up to Panamax size.

$$kW = \gamma_0 S^{\gamma_1} V^{\gamma_2} \quad (6)$$

In accordance with the equation (8) above, it can be derived to another formula for measuring fuel consumption rate also with the assumption that the ship moves under its own designed speed (V). As for the result of regression analysis, the elasticity value of β1 is 0.174 for all ships classified up to Panamax size.

$$Ln(V) = \beta_0 . Ln(S^{\beta_1}) \quad (7)$$

Veldman (2011) figured out using container fleet data in 2008 that the design service speed varies between 16 and 25 knots for the vessel up to 6000 TEU. The bunker price will benchmark based on Singapore bunker market data. Meanwhile, it is assumed that lubricant cost is about 3% of total fuel cost (Veldman, 2011). We corresponded our primary data for design speed and engine power of 1000 TEU vessel with a value of 17.5 knots and 9,800 kilowatts respectively as shown in the figure 5.

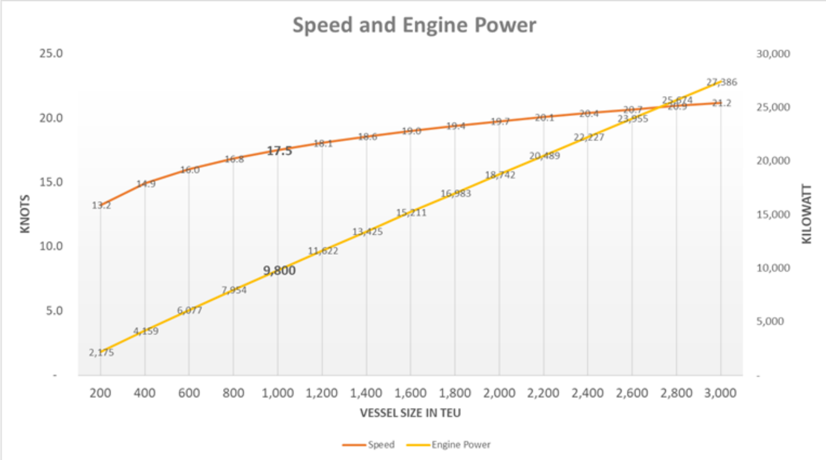

Figure 5. Regression of Speed and Engine Power

The last part that connected with changes in the vessel size is cargo handling speed (H) based on how many cranes deployed to handle a ship in port. Bigger ships need a longer time to finish loading and unloading movement. Thus, they tend to spend more time in port. Factors like crane productivity, how many cranes work simultaneously, the capability of the crane's hold to lift the containers and even the slack time in the date of arrival and departure of the vessel. The following equation shows the relationship between handling speed and ship's size.

$$H = \varepsilon_0 S^{\varepsilon_1} \tag{8}$$

Assuming that the ratio of length, beam and depth of a ship are constant which making the speed to move cargoes is proportional to the size of the vessel. Thus, according to the theoretical approach, the elasticity value of ε1 is equal to one-third as no other reliable and accurate values have been published (Veldman, Liu and Garcia-Alonso, 2016).

Value of Time (VOT)

VOT is the opportunity cost of the cargo during transportation process (Zamparini and Reggiani, 2007) which tends to have a substantial impact on the proportion of whole transport cost especially after slow steaming effect (Notteboom and Cariou, 2013). For instance, a carrier who has a long time caused by a detour of his transport mode is directly reflected in the equipment costs and enforce wages (Tavasszy, 1996). Lower transport time may reduce total transportation cost. Therefore, in order to estimate the adapted VOT, thereafter, we used a proxy that combines an assumption of the average value of 1 TEU container multiplied by the interest rate. We assume that the value of one containerised cargo is $100,000 whereas the yearly interest rate used is 10%. Therefore, we get the adapted VOT of $ 27.40/TEU/day as the product between cargo's value and interest rate needs to be divided by the number of days in one year.

After discussing all the methodology above, we will calculate the total generalised cost of the current Indonesian domestic shipping network. Afterwards, we will conduct the same method to predict the future situation assuming there will be an improvement in network efficiency using the Sea-Tollway concept of the Indonesian government. The difference between the generalised cost of the current situation and the future situation will be utilised as Non-Tariff Measure (NTM) treatment that might be done by Indonesia government to manifest the result of this study into reality.

3. Results and Discussions

After extracting results from all equations above, we can determine other cost components with such liberalisation in annual basis as shown in Figure 6. The yearly crew costs form a fixed straight line of 0.62 million US Dollars. Whereas, the other cost such as repair and maintenance, insurance, administrative and management shape an upward trend as the size increase. Together, these expenses will constitute the annual operational and capital-related costs.

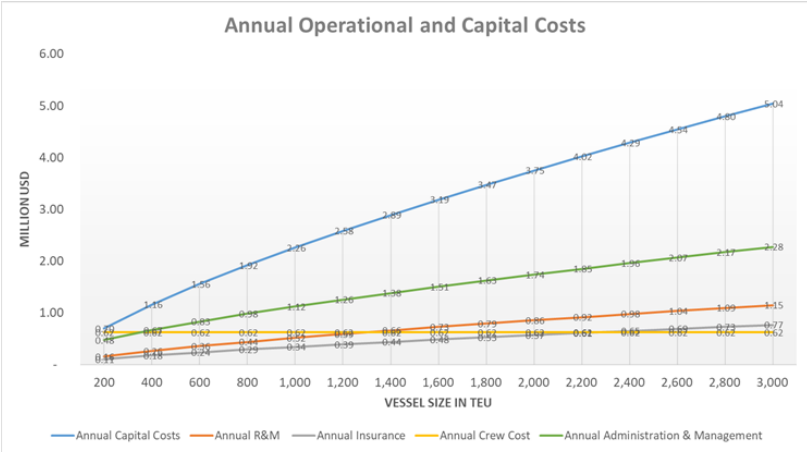

Figure 6. Annual Operational and Capital Costs

The domestic liner routes are mainly centralised in three big cities of Jakarta, Surabaya and Makassar. Additionally, the routes which connecting ten major container ports as indicated in Table 2 are labelled as main liner routes. Meanwhile, the other routes are considered as supporting routes. The current model mostly follows port-to-port model leading to chaotic network with several routes serving the same destination from different sources. Also, with no distinct function of hub port for domestic trade, it is highly likely that the total cost of connecting ten major container ports as shown by red, blue and yellow lines below is higher compared to the expected situation of Sea-Toll concept from Bappenas that follows the hub and spoke model.

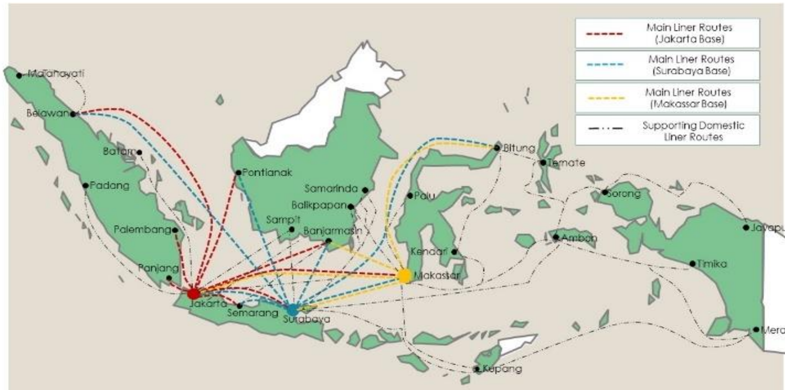

Figure 7. Current Indonesian Domestic Shipping Network

Source: Author's illustration based on Indonesian container shipping lines (SPIL, Meratus, Tanto, Temas, etc)

In the current condition as shown in figure 7, the total cost per trip in maritime leg tend to increase as longer transport time due to high fuel consumption needed. Ideally, shipping companies have to have a larger vessel for the long-distance voyage, since a mega ship has bigger engine power resulting in more top speed. Thus, it can reduce total time spent on sea meaning that it can lower the fuel cost significantly. On the other hand, total cost incurred in port area will highly depend on how the port handle the loading-unloading process or in this model it is defined through the level of crane productivity. Whereas for current condition Indonesian Ports could handle between 20-25 moves per hour per crane in average.

Table 4 The Result of Monetary Cost per TEU of Current Condition in Maritime Leg and Port Area

Route Based on Port-to-Port Model	Distance (nautical mile	Vessel Size by Model Approach (TEU)	Call Size (TEU)	Time at Sea & Ports (days)	Monetary Cost (USD/TEU)		
					Maritime Leg	Port of Origin	Port of Destination
Jakarta Base							
Jakarta - Belawan	827	1600	1280	3.94	$ 50.58	$67.12	$70.30
Jakarta - Palembang	341	600	480	2.14	$ 31.62	$65.09	$68.05
Jakarta - Panjang	118	400	320	1.33	$ 13.30	$64.99	$67.29
Jakarta - Semarang	237	200	160	1.48	$ 38.88	$66.04	$68.55
Jakarta - Surabaya	388	1000	800	2.48	$ 28.73	$65.85	$67.47
Jakarta - Pontianak	411	400	320	2.21	$ 46.31	$64.99	$66.32
Jakarta - Banjarmasin	519	400	320	2.41	$ 58.48	$64.99	$66.23
Jakarta - Makassar	785	1200	960	3.48	$ 53.89	$66.28	$66.89
Surabaya Base							
Surabaya - Belawan	1105	1200	960	4.45	$ 75.85	$67.99	$69.18
Surabaya - Semarang	187	200	160	1.35	$ 30.68	$67.20	$68.55
Surabaya - Pontianak	551	400	320	2.55	$ 62.08	$66.28	$66.32
Surabaya - Banjarmasin	273	400	320	1.77	$ 30.76	$66.28	$66.23
Surabaya - Makassar	444	1000	800	2.65	$ 32.88	$67.47	$66.43
Surabaya - Bitung	1076	1400	1120	4.58	$ 69.39	$68.50	$71.08
Makassar Base							
Makassar - Banjarmasin	337	400	320	1.92	$ 37.97	$65.45	$66.23
Makassar - Bitung	782	800	640	3.46	$ 63.73	$65.98	$69.14
			Total	**42.10**	**$ 725.11**	**$1,060.52**	**$ 1,084.24**

For the future condition, this paper will follow the Sea-Toll concept based on National Medium-Term Development Plan or RPJMN in 2016 where there will 5 ports that will act as hub ports (Belawan/Kuala Tanjung, Tanjung Priok, Tanjung Perak, Makassar and Bitung) and the remaining 19 ports will act as feeder ports. These ports are deliberately chosen to vastly improve connectivity of the nation and to accelerate economic growth especially in eastern part of Indonesia. In this model, the function of each port has been explicitly resolved to minimise the possibility of cross mixing services of shipping services. With an integrated network, bigger vessel deployed and better port performance level, it is expected that the total generalised cost of domestic shipping in Indonesia will be reduced considerably.

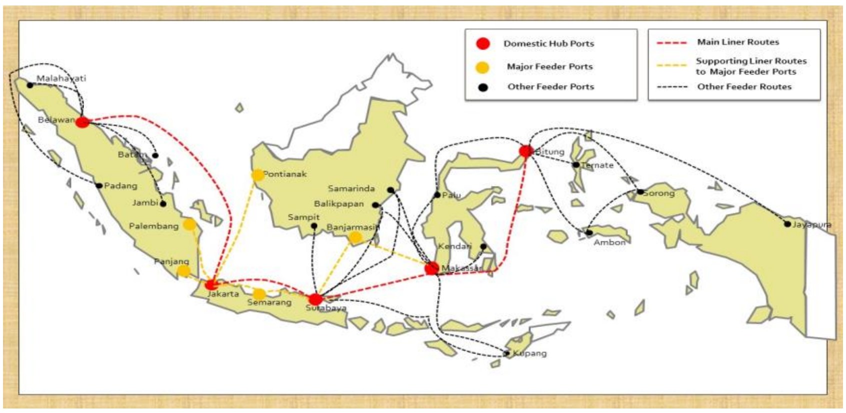

Figure 8. Indonesian Sea-Toll Concept Map *Source*: Author’s illustration based on BAPPENAS, 2015

In the future condition, we defined that the projected vessel size deployed is 3000 TEU considering the very long distance from Belawan to Bitung and another study about the optimal vessel size of Pendulum service from Drewry (2012) as a benchmark. Whereas, for the supporting liner routes as shown in figure 8, we assume that the size of the ship will also increase at least twice bigger, proportionally to a rise in multiport call.

Table 5 The Result of Monetary Cost per TEU of Future Condition in Maritime Leg and Port Area

Route	Projected vessel size (TEU)	Distance (nautical mile)	Time at Sea and Ports (days)	Monetary Cost (USD/TEU)		
				Maritime Leg	Port of Origin	Port of Destination
Main Liner Routes (Multiport Call)						
Belawan - Jakarta - Surabaya - Makassar - Bitung	3,000	2441	11.15	$110.74	$262.21	$262.21
Supporting Liner Routes						
Jakarta-Panjang	800	118	1.47	$9.05	$63.36	$63.36
Jakarta-Palembang	1,200	341	2.26	$22.03	$64.01	$64.01
Jakarta-Semarang	400	237	1.50	$25.13	$63.11	$63.11
Jakarta-Pontianak	1,000	411	2.32	$28.64	$63.67	$63.67
Surabaya-Banjarmasin	1,000	273	1.99	$19.03	$63.67	$63.67
Surabaya-Semarang	400	187	1.36	$19.83	$63.11	$63.11
		Total	**22.05**	**$234.46**	**$643.13**	**$643.13**

After calculating the real incurred expenses or monetary cost as shown in Table 4 and Table 5 above, then we should have calculated the non-monetary cost that represented by the Value of Time for each route in order to have the whole package of generalised cost model. Afterwards, we made a comparative analysis between current and future condition that show both of cost and time for the selected routes in this study. However, in order to make the apple-to-apple comparison, we will only compare the existing shipping routes with those that are selected in the future condition or Sea-Toll program. Moreover, in order to give more impression to the real case, the following generalised cost will be calculated in the form of roundtrip that covers trip from port of origin to port of destination and comeback to port of origin again.

Table 6 Comparative Result

Route	Generalised Cost per Roundtrip (USD/TEU)		Cost Saving		Time Spent per Roudtrip (Days)	
	Current	Future	USD /TEU	%	Current	Future
Multiport call	$2,117.96	$1,357.94	$(760.01)	-35.88%	25.06	22.31
Jakarta - Panjang	$364.00	$352.42	$(11.57)	-3.18%	2.66	2.95
Jakarta -Palembang	$509.97	$423.98	$(85.99)	-16.86%	4.28	4.52
Jakarta – Semarang	$428.08	$384.92	$(43.16)	-10.08%	2.96	3.00
Jakarta - Pontianak	$470.89	$438.69	$(32.20)	-6.84%	4.22	4.63
Surabaya - Banjarmasin	$423.56	$401.46	$(22.11)	-5.22%	3.54	3.97
Surabaya - Semarang	$407.02	$366.66	$(40.36)	-9.92%	2.71	2.72
Total	**$4,721.48**	**$3,726.08**	**$(995.40)**	**-21.08%**	**45.43**	**44.10**

Table 6 derived that the cost saving per roundtrip as aggregate value for the first scenario is about $995.40 per TEU per roundtrip or plunge by 21.08% than compared to the current condition. The most considerable decline is contributed by a change between five internal hub ports which using a multiport call. Whereas, Jakarta – Panjang route has no significant change with only 3.18% decrease. But this is not a major problem, as the shipment to Panjang port does not always have to be with a container ship, it also can be done using a truck by Ro-Ro vessel. The same situation as all direction to and from Semarang in accordance with either Jakarta or Surabaya. Last but not least, the timesaving is achieved using the multiport call with 1.33 days or 2.93% lower than initial figure.

4. Conclusion

We conclude that in the current condition, the shipping network in Indonesia is quite problematic with many cross-mixed services serving the same destination. In addition, the Indonesian shipping network is also restricted by infrastructure boundaries leading to relatively small vessels moving around the country, although there are also some exceptions in the presence of large ships ranging from 1400 to more than 2000 TEU serving certain lines.

On the other hand, in the future condition assuming that a 3000-TEU vessel with 80% load factor is deployed to serve five domestic hub ports and the remaining feeder ports will use proportionate size but still bigger than the current condition to have the economies of scale advantage. The result showed that the total cost-saving for the selected routes is $ 995.40 per TEU per roundtrip and even the total time spent to fulfil the whole roundtrip is decreased by 1.33 days.

The results from this study have provided such a close guesstimate to the real situation. Although in the process of building the generalised cost model, there are lot of challenges that need to be noticed such as the variables included in the calculation and the accuracy of the data itself. However, this study successfully discloses that there will be an improvement in cost efficiency by implementing the Sea-Toll for Indonesian domestic shipping networks. The reduction in cost will then stimulate and support a local trade between Indonesian regions, as predicted by the study of Drewry (2012). Consequently, it will also lead to a better performance in the whole logistic fulfilment and diminish the economic gap between the eastern and western part of Indonesia.

We also recommend that aside from prioritising their policies in the improvement of infrastructure, the government should consolidate the vision of the Sea-Toll project for the private actors. Since they may not have the same approach in doing their business with the national interest, hence, the government should take an early initiative to attract the willingness of private parties. One significant step has been done which is a subsidy in certain liner routes. This will stimulate the participation of shipping companies. Another is conducting different public-private mechanisms such as Build-Own-Transfer (BOT) or Build-Own-Operate-Transfer (BOOT).

With a limited amount of time to work on this project, the author is aware of the limitation of this study. The author hopes that this study can be a stepping-stone for further research in the development of Indonesia. Thus, dynamic simulation of possible liner routing or even the optimal vessel size to serve each one of the routes is a necessary future empirical improvement. The interaction with weather variables in Indonesia also could be the best way to predict the transport cost. Lastly, the environmental factor perhaps should be included in the non-monetary cost, as its effects might significantly affect other perceived values of both customer and business actors. Therefore, a dedicated research in the future for a better and integrated improvement from this study is highly recommended.

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